WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Currant Creek Instream Flow Studies

PROJECT: FX-GR-3ES-511

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ABSTRACT

Studies conducted during 1997 and 1999 determined instream flows necessary for maintaining Colorado River cutthroat trout (CRC) habitat and populations. Physical Habitat Simulation (PHABSIM), the Habitat Quality Index (HQI), and the Habitat Retention Method were used in deriving instream flow water right recommendations of: October 1 - April 15 = 1.2 cfs, April 16 - June 30 = 11 cfs, and July 1 - September 30 = 3.6 cfs.

INTRODUCTION

Wyoming's instream flow law (W.S.41-3-1001) defines the Wyoming Game and Fish Department's (WGFD) role in identifying instream flow levels necessary to maintain important fisheries. According to the law, unappropriated flowing water "may be appropriated for instream flows to maintain or improve existing fisheries..." (W.S.41-3-1001(b)). WGFD instream flow recommendations must be for specific stream segments and seasons. These recommendations are incorporated into an instream flow water right application and, as provided by statute, may become an instream flow water right held by the state of Wyoming. This process ensures that adequate stream flow is protected when it is available in priority so that important fisheries will persist.

Since the law was passed in 1986 and through 1999, WGFD has submitted 79 instream flow water right applications, 12 have been approved by the state engineer, and 2 formally adjudicated. Initially, efforts focused on WGFD class 1 and 2 waters, which are highly productive and provide popular recreational opportunities. More recently, efforts have shifted toward small headwater streams supporting native cutthroat trout.

Wyoming has historic ranges for Bonneville cutthroat trout (*Oncorhynchus clarki utah,* sometimes locally referred to as "Bear River" cutthroat trout), Colorado River cutthroat trout (*O.clarki pleuriticus*), and Yellowstone cutthroat trout (*O.clarki bouvieri*). A variant of Yellowstone cutthroat trout, the Snake River cutthroat trout, also occurs in the northwest portion of the state. Since the early 1990s, instream flow studies have been done on many stream segments throughout the native range of

Bonneville and Colorado River cutthroat trout. This report includes results and recommendations from studies on Currant Creek, a Colorado River cutthroat trout stream.

The historic distribution and conservation status of Colorado River cutthroat trout is reviewed in Young (1996) and Nesler et al. (1999). In Wyoming, historic range includes streams tributary to the Green River: the Little Snake River drainage on the west side of the Sierra Madre mountains, Green River tributaries draining the east face of the Wyoming Range mountains, the Blacks Fork River and its tributaries arising in the Uinta mountains, and a few tributaries like Currant Creek that flow directly into the Green River from the east. Prior to 1997, instream flow studies were conducted in the major drainages of the Wyoming Range and Sierra Madre mountains. During 1997, additional studies were conducted in Blacks Fork and east-side Flaming Gorge tributaries like Currant Creek. Finally, Currant Creek was studied again in 1999 and the data collected provide the basis for this report.

A conservation plan was developed by Wyoming, Colorado, and Utah state wildlife agencies, in coordination with the U.S. Fish and Wildlife Service, to guide conservation efforts in the tri-state area through three primary activities: protecting existing and restored ecosystems, restoring degraded ecosystems, and planning (Nesler et al. 1999). The process of acquiring and maintaining suitable instream flows is listed as a strategy for restoration. Obtaining instream flow water rights to be held by the state of Wyoming will provide assurance that available water will be reserved when it is available in priority for providing CRC habitat. Such efforts do not increase habitat from present levels or ensure that adequate habitat is available; instead, they act to avoid future water depletions up to the limits established by instream flow water rights. Instream flow water right acquisition is just one step in a comprehensive process of protecting and conserving native cutthroat trout habitat and populations.

Study objectives were to 1) investigate the relationship between discharge and physical habitat quantity and quality for Colorado River cutthroat trout in Currant Creek and, 2) determine an instream flow regime that will help maintain the Currant Creek Colorado River cutthroat trout fishery.

METHODS

Study Area

Currant Creek is located in southwest Wyoming in Sweetwater County, south of Rock Springs. It flows north and then west before entering the Green River at Flaming Gorge Reservoir (Figure 1). Land ownership in the Currant Creek basin is a mix of private, state, and Bureau of Land Management (BLM) but most parcels abutting the proposed instream flow segment are State and BLM- administered except for a privately owned parcel near the downstream end of the segment. The upper boundary of the proposed instream flow segment is at about elevation 7,680 feet and is marked by the confluence of the east and middle forks of Currant Creek at Township 13N, Range 106W, Section 1, NE1/4. This point marks a location where the creek is fully formed from its primary springs. The downstream boundary for the proposed instream flow segment is at Dry Hollow at the border between private and BLM at Township 14N, Range 106W, Section 5, SW1/4. This marks the lowest point on Currant Creek for which water temperatures and habitat presently appear suitable for sustaining CRC populations.

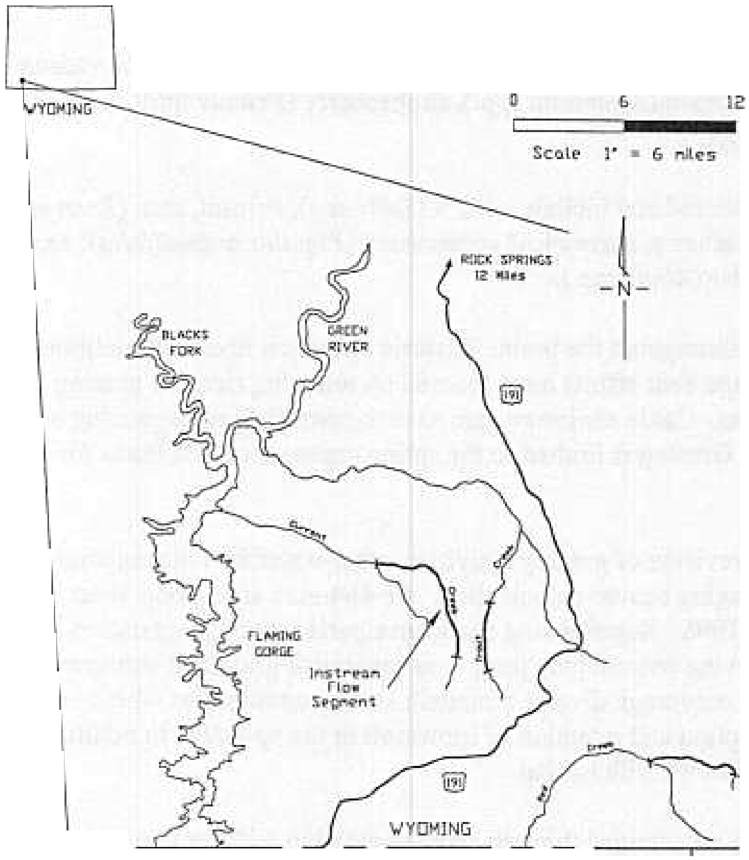

Figure 1. Area map showing the Currant Creek instream flow segment.

Currant Creek originates from springs and small headwater tributaries on Pine Mountain with elevations of over 9,000 feet in the basin. The drainage aspect is generally north facing at higher elevations and veers to west facing for approximately 12 miles before ending at Flaming Gorge Reservoir at an elevation of about 6,000 feet. Much of the drainage is steep and highly dissected corresponding to Rosgen and Silvey's (1998) valley type VII. The Currant Creek basin overlies deposits of the Eocene Green River formation that is a fine-grained, erosive sedimentary rock (Lageson and Spearing 1988). Soils derived from this material are unstable and prone to rapid erosion. Localized and severe channel down cutting has been an ongoing problem when excessive stream energy during snowmelt run-off combines with disturbed and naturally erosive soils. For example, WGFD and the Currant Creek Ranch landowner have been battling a head-cut near the downstream end of the proposed instream flow segment for several years by placing rock in the channel. Stopping such erosion is important for maintaining a naturally meandering channel with abundant trout habitat rather than a straight, steep channel supporting very little habitat.

Headwaters are dominated by subalpine fir (*Abies lasiocarpa*) with some lodgepole pine (*Pinus contorta*) and scattered aspen. This likely represents a climax community resulting from fire suppression during most of this century. An earlier successional stage of aspen-dominated vegetation likely prevailed in the past (Kevin Spence, WGFD, pers. comm.). Upland vegetation from Dry Hollow upstream is approximately 75% sagebrush-grassland, 5% juniper, and 15% mountain shrub, and 5% aspen communities (Kevin Spence pers comm.). Representative shrubs include mountain mahogany

(*Cercocarpus montanus*), snowberry (*Symphoricarpos albus*), antelope bitterbrush (*Purshia tridentata*), rabbitbrush (*Chrysothamnus* spp.), sagebrush (*Artemesia* spp.), chokecherry (*Prunus* spp), serviceberry (*Anelanchier* spp.), and currant (*Ribes* spp.).

Riparian woody species are scattered and include willow (*Salix* spp), currant, rose (*Rosa* spp.), water birch (*Betula occidentalis*), chokecherry, narrowleaf cottonwood (*Populus angustifolia*), aspen (*Tremuloides* spp.), and a very little alder (*Alnus* spp.).

Currant Creek Ranch operates throughout the basin. Historic operation involved traditional cow/calf yearlong use. Recently, management efforts have focused on relieving riparian grazing pressure on BLM, state and private plots. Cattle exclosures are used to control riparian grazing at Dry Hollow and upstream BLM segments. Grazing is limited to the spring season on BLM lands for one out of every three years.

In addition to curtailment and revision of grazing activities, other watershed management actions include prescribed burning and encouraging beaver colonization. An 864-acre area along West Fork Currant Creek was 65% burned in fall 1996. Regenerating decadent riparian woody vegetation and enhancing watershed function by removing encroaching juniper in sagebrush/grassland communities were the primary goals. Mosaic burns encourage diverse mountain shrub communities which improve ground cover and result in better absorption and retention of snowmelt in the uplands. In addition, the increased vegetational diversity improves wildlife habitat.

Beaver re-colonization is being encouraged through supplementation with large woody materials to support solid dam construction. Surveys recently conducted show that active beaver dams have increased from 7 in 1992 to 37 in 1997 (Annual Fisheries Progress Report, 1998). A goal of beaver management is elevated water tables thereby encouraging the establishment of additional woody species. Additional benefits include stabilized banks, reduced sediment sloughing from banks, and deep pools for overwintering trout.

The stream channel is incised throughout much of the segment and laterally constrained by its banks. Stream type under Rosgen and Silvey (1998) was characterized as G4, reflecting the following conditions: instability due to high sediment supply from both upslope and channel derived sources, moderate gradient, low width to depth ratio, and gravel dominated channel with mixtures of sand and some cobble. Channel features vary in isolated reaches, especially in Janes Meadow. Here, alluvial deposits in a wide valley resulted in a low gradient meadow reach of less than 1/2 mile in length. Trout habitat improvement and channel improvement structures have resulted in deep pools and decreased channel incision. In fact, new channels have been cut at the head of the meadow in recent years following high flows and substrate scour and deposition.

Hydrology

Watershed climate is semi-arid with 10-14 inches of annual precipitation in the headwaters and lesser amounts at lower elevations. Snowmelt run-off typically peaks in May while springs sustain baseflow the rest of the year. Biologists familiar with the area note that Currant Creek appears to have a modulated runoff pattern such that high flows occur over an extended period well into summer (Mark Fowden, personal communication). Such a pattern confounded data collection in 1997 because discharge did not drop to a sufficiently low level by late summer. High summer flow levels were again apparent in 1998 and 1999 (Appendix 1).

A stage-recording gage was placed in Currant Creek at the downstream end of the proposed instream flow segment in early May 1998. Overbank flows in late May and June changed the channel, deposited sediment, and rendered chart recordings unusable. In 1999, a recording gage was installed June 15 (after peak run-off) and operated continuously through October 12, 1999. The resulting hydrograph is included in this report as Appendix 1. Also included in Appendix 2 is a table listing all point discharge measurements collected from 1996 through 1999.

Fisheries

Currant Creek records indicate trout stocking occurred in 1935 but the species stocked was not recorded. Cutthroat trout (subspecies not recorded but probably Snake River or Yellowstone cutthroat trout) were stocked in 1937 and brook trout in 1939 with continued stocking of cutthroat and brook trout through the mid 1970s. Stocking of Snake River and Yellowstone cutthroat trout was discontinued in 1976 in many southwest streams, including Currant Creek, due to poor survival and recruitment. In conjunction with habitat improvement work, CRC were stocked annually in 1990-1992, and 1994.

In response to low population densities and degraded habitat, Currant Creek was closed to angling in 1990. Population surveys conducted in 1997 from two stations upstream of Jane's Meadow resulted in estimates of 276-337 CRC/mile (50 - 117 lbs/acre). Brook trout at these stations ranged between 70 and 97 BKT/mile (15-16 lbs/acre). Surveys conducted in 1996 in Janes Meadow and Dry Hollow showed CRC numbers at 165 - 245 per mile (67 - 71 lbs/acre). Given the favorable population densities and recovering habitat, the fishery was opened to angling again in 1998.

It is commonly found that trout population density in small mountain streams fluctuates annually (House 1995, Mueller 1987). Such changes in abundance are related to natural variation in environmental factors like flow level and timing, temperature, and abundance of predators and competitors. If adequate habitat exists, populations survive during periods of hardship such as drought and flourish during periods with better conditions. In Currant Creek, steps are being taken to increase the minimum and maximum population potential by improving the watershed and channel. This will decrease the chances of CRC extinction during a low point in their population cycle. Under this framework, long-term trout population maintenance depends on periodic strong year classes produced in good flow years. Without benefit of periodic favorable flows, populations might decline or disappear. The WGFD instream flow strategy recognizes the inherent variability of trout populations and thus defines the "existing fishery" as a dynamic feature. Instream flow recommendations are based on a goal of maintaining habitat conditions that provide the opportunity for trout numbers to fluctuate within existing natural levels.

Habitat Modeling

A representative study site was located at Township 14N, Range 106W, Section 5, SE1/4 on June 15, 1999. The site contained trout cover associated mostly with lateral scour pools and grassy banks. Three transects were established, each on a different riffle. The transects were used to simulate depths and velocities over a range of discharges for Habitat Retention analysis (below) and evaluating spawning potential. Data for calibrating simulations were collected between June 15 and September 21, 1999 (Table 1).

Table 1. Data collection dates for Currant Creek instream flow data.

Date	Discharge (cfs)
June 15, 1999	18
July 2, 1999	12
July 26, 1999	6.6
September 21, 1999	4.4

Determining critical trout life stages (fry, juvenile, adult, etc.) for a particular time period aids in focusing flow recommendations. Critical life stages are those most sensitive to environmental stresses. Annual population integrity is sustained by providing adequate flow for critical life stages. In many cases, trout populations are constrained by spawning and young (fry and juvenile) life stage habitat "bottlenecks" (Nehring and Anderson 1993). Therefore, our general approach includes ensuring that adequate flows are provided to maintain spawning habitat in the spring was well as juvenile and adult habitat throughout the year (Table 2).

Table 2. Colorado River cutthroat trout life stages and months considered in Currant Creek instream flow recommendations. Numbers indicate method used to determine flow requirements.

Life Stage	Jan	Feb	Mar	Apr 1 to Apr 15	Apr 16 to Apr 30	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult								1	1	1			
Spawning					2	2	2						
All	3	3	3	3	3	3	3	3	3	3	3	3	3

= Habitat Quality Index; 2 = PHABSIM; 3 = Habitat Retention

Habitat Retention Method

A Habitat Retention method (Nehring 1979; Annear and Conder 1984) was used to identify a maintenance flow by analyzing data from hydraulic control riffle transects. A maintenance flow is defined as the continuous flow required to maintain specific hydraulic criteria in stream riffles. Year-round criteria maintenance in riffles ensures that habitat is also maintained in other habitat types such as runs or pools (Nehring 1979). In addition, maintenance of identified flow levels may ensure passage between habitat types for all trout life stages and maintain adequate benthic invertebrate survival.

A maintenance flow is realized at the discharge for which any two of the three criteria in Table 3 are met for all riffle transects in a study area. The instream flow recommendations from the Habitat Retention method are applicable year round except when higher instream flows are required to meet other fishery management purposes (Table 2).

Table 3. Hydraulic criteria for determining maintenance flow with the Habitat Retention method.

Category	Criteria
Mean Depth (ft)	Top Width[a] X 0.01
Mean Velocity (ft/s)	1.00
Wetted Perimeter (%)[b]	50

a - At average daily flow or mean depth = 0.20, whichever is greater
b - Percent of bank full wetted perimeter

Simulation tools and calibration techniques used for hydraulic simulation in PHABSIM (Physical Habitat Simulation) are also used with this technique. The PHABSIM method uses empirical relationships between physical variables (depth, velocity, and substrate) and suitability for fish to derive weighted usable area (WUA; suitable ft^2 per 1,000 ft of stream length) at various flows. The habitat retention method involves analysis of hydraulic characteristics at control riffles. The AVPERM model within the PHABSIM methodology is used to simulate cross section depth, wetted perimeter and velocity for a range of flows. The flow that maintains 2 out of 3 criteria for all three transects is then identified.

Habitat Quality Index

The Habitat Quality Index (HQI; Binns and Eiserman 1979; Binns 1982) was used to estimate trout habitat levels over a range of late summer flow conditions. This model was developed by the WGFD and has been reliably used in Wyoming for trout standing stock gain or loss assessment associated with instream flow regime changes. The HQI model includes nine attributes addressing biological, chemical, and physical aspects of trout habitat. Results are expressed in trout Habitat Units (HUs), where one HU is defined as habitat to support about 1 pound of trout. HQI results were used to identify the flow needed to maintain existing levels of Colorado River cutthroat trout habitat quality between July 1 and September 30 (Table 2).

In the HQI analysis, habitat attributes measured at various flow events are assumed to be typical of mean late summer flow conditions. For example, stream widths measured in June under high flow conditions are considered a fair estimate of the stream width that would occur if the same flow level occurred in the month of September. Under this assumption, HU estimates are extrapolated through a range of potential late summer flows (Conder and Annear 1987). Currant Creek habitat attributes were measured on the same dates PHABSIM data were collected (Table 1). Some attributes were mathematically derived to establish the relationship between discharge and trout production at discharges other than those measured.

A Ryan temperature recorder monitored water temperature at 4-hour intervals between June 5 and August 25, 1997 at Jane's Meadow and between July 27 and September 21, 1999 at Dry Hollow. A peak flow estimate (136 cfs) for determining annual stream flow variation (ASFV) was based on elevation and basin area (Lowham 1988). When the same method was applied to calculate average daily flow (ADF), an estimate of 11.5 cfs resulted. This value appeared high compared to observed flow levels (Appendices 1 and 2). Therefore, ADF was approximated as 6 cfs based on measured values. The HQI analysis was not sensitive to which ADF estimate was used, i.e. the flow recommendation resulting from HQI analysis would not have changed regardless of which ADF estimate was used.

Physical Habitat Simulation

Physical Habitat Simulation (PHABSIM) methodology was used to quantify physical habitat (depth and velocity) availability for life stages over a range of discharges. The methodology was developed by the Instream Flow Service Group of the U.S. Fish and Wildlife Service (Bovee and Milhous 1978) and is widely used for assessing instream flow relationships between fish and physical habitat (Reiser et al. 1989).

The PHABSIM method uses empirical relationships between physical variables (depth, velocity, and substrate) and suitability for fish to derive weighted usable area (WUA; suitable ft^2 per 1,000 ft of stream length) at various flows. Depth, velocity, and substrate were measured along three transects (*sensu* Bovee and Milhous 1978) on the dates in Table 1. Hydraulic calibration techniques and modeling options in Milhous et al. (1984) and Milhous et al. (1989) were employed to incrementally estimate physical spawning habitat between 0.6 and 45 cfs.

Curves describing depth, velocity and substrate suitability for trout life stages are an important component of the PHAMSIM modeling process. The spawning suitability curves used for deriving instream flow recommendations are listed in Appendix 3. Observations by WGFD biologists indicate spawning activity in Currant Creek likely peaks in May during most years. Because spawning onset and duration varies between years due to differences in flow quantity and water temperature, spawning flow recommendations should extend from April 16 to June 30. Even if spawning is completed before the end of this period, maintaining flows at a selected level throughout June will benefit trout egg incubation by preventing dewatering. The PHABSIM model was used in making flow recommendations for maintaining spawning habitat from April 16 to June 30 (Table 2).

RESULTS AND DISCUSSION

Trout populations are often naturally limited by extreme conditions during the winter months (October through March; Needham et al. 1945, Reimers 1957, Butler 1979, Kurtz 1980, Cunjak 1988, Cunjak 1996, Annear et al. 1999). Frazil ice (suspended ice crystals formed when water is chilled below 0°C) in high gradient stream reaches can be both a direct mortality source through gill abrasion and subsequent suffocation or an indirect mortality source when resultant anchor ice limits habitat, causes localized de-watering, and exerts excessive metabolic demands on fish forced to seek ice-free habitats (Brown et. al 1994). Pools downstream from high gradient frazil ice-forming areas can accumulate anchor ice (Brown et. al 1994, Cunjak and Caissie 1994). Such accumulations may result in mortalities if low winter flows or ice dams block emigration.

Super-cooled water (<0° C) can also physiologically stress fish. As temperatures decrease to low levels, fish gradually lose ion exchange abilities. At water temperatures near 0° C, fish have limited ability to assimilate oxygen or rid cells of carbon dioxide and other waste products. If fish are forced to be active near 0°C, such as to avoid frazil ice, direct mortalities can occur. The extent of impacts depends on the magnitude, frequency and duration of frazil events and the availability of escape habitats (Jakober et al. 1998). Juvenile and fry life stages tend to be impacted more than larger fish because younger fish inhabit shallower habitats and stream margins where frazil ice accumulates. Larger fish that inhabit deep pools may endure frazil events if they are not displaced.

Refuge from frazil ice occurs in groundwater influx areas, ice covered pools not close to frazil ice sources, and where heavy snow cover and stream bridging reduces frazil formation (Brown et al. 1994). Lower gradient streams and narrow streams are more likely to have insulating surface ice cover or at higher elevations, heavy snow cover and bridging. Currant Creek's high elevation, relatively narrow width and moderate slope suggest that snow bridging occurs in the headwaters. However, frazil events can occur in early winter before sufficient insulating snow is present or in late winter when snow melt becomes superchilled by flowing over snow and ice before entering the stream. Therefore, natural winter flow levels up to the identified 1.2 cfs (below) should be maintained to maximize access to and availability of frazil-ice-free refugia. Any artificial reduction of natural winter stream flows could increase trout mortality, reduce the number of fish the stream could support, and degrade the existing fishery.

Habitat Retention Analysis

Maintenance of naturally occurring flows up to 1.2 cfs is necessary at all times of the year (Table 4). On riffle 1, 2 of 3 criteria (velocity and wetted perimeter) were met at a discharge of 1.2 cfs. On riffle 2 the discharge that satisfied 2 of 3 criteria was 0.9 cfs. For riffle 3 the discharge that met 2 of 3 criteria was 1.0 cfs. Therefore, the discharge that meets 2 of 3 criteria for all riffles is 1.2 cfs.

The 1.2 cfs identified by the Habitat Retention Method may not always be present during the winter. Because the existing fishery is adapted to natural flow patterns, occasional shortfalls during the winter do not imply any degree of infeasibility or a need for additional storage. Instead, they illustrate the necessity of maintaining all natural winter stream flows, up to 1.2 cfs, to maintain existing trout survival rates. Results from the HQI and PHABSIM methods below indicate that higher flows are needed during April through September to support spawning and adult life stages.

Habitat Unit Analysis

Article 10, Section d of the Instream Flow Act states that waters used for providing instream flows "shall be the minimum flow necessary to maintain or improve existing fisheries". One way to define "existing fishery" is by the number of habitat units that occur under normal July through September flow conditions. Since there is no long-term, historical stream flow gage on Currant Creek, an estimate for discharge over the July through September period can be derived from point measurements collected during instream flow studies (Appendices 1 and 2). These data suggest that 4 to 7 cfs typically flows in Currant Creek at Dry Hollow during July through September. Flows in that range provide 42 to 49 habitat units (Figure 3). The lowest flow that will maintain this level of habitat units is 3.6 cfs.

Based on this analysis, an instream flow of 3.6 cfs between July 1 and September 30 would maintain existing trout habitat quality. This flow represents the lowest stream flow that will accomplish this objective if all other habitat attributes remain unchanged. The existing fishery is naturally dynamic as a function of stream flow availability. In years when stream flow is naturally less than 3.6 cfs in late summer the fishery declines. Likewise, in years when late summer flow is 3.6 cfs or more, it expands. As noted above, maintaining this existing fishery simply means maintaining existing natural stream flows up to the recommended amount in order to maintain the existing natural habitat and fish population fluctuations.

Table 4. Simulated hydraulic criteria for three Currant Creek riffles at selected discharge levels.

	Mean Depth (ft)	Mean Velocity (ft/s)	Wetted Perimeter (ft)	Discharge (cfs)
Riffle 1	1.21	3.80	10.4	40
	0.97	2.82	8.5	20
	0.84	2.48	8.2	15
	0.66	2.14	7.8	10
	0.43	1.71	7.1	5.0
	0.24	1.35	6.3	2.0
	0.20[a]	1.26	5.7	1.4
	0.19	1.22	**5.3**[a]	**1.2**[b]
	0.17	1.08	4.3	0.8
	0.15	**0.99**[a]	4.2	0.6
Riffle 2	1.15	4.21	9.7	40
	0.80	3.23	8.6	20
	0.69	2.92	8.3	15
	0.54	2.64	7.6	10
	0.41	2.12	6.3	5
	0.24	1.20	5.1	1.4
	0.23	1.13	**4.9**[a]	1.2
	0.21	**1.01**[a]	4.6	**0.9**[b]
	0.20[a]	0.97	4.4	0.8
	0.18	0.87	4.1	0.6
Riffle 3	1.14	4.10	11.4	40
	0.86	2.96	10.3	20
	0.75	2.58	10.0	15
	0.53	2.50	8.0	10
	0.37	1.84	7.7	5
	0.24	**1.04**[a]	6.0	1.4
	0.22	0.95	5.8	1.2
	0.21	0.86	**5.7**[a]	**1.0**[b]
	0.20[a]	0.82	5.6	0.9
	0.19	0.77	5.6	0.8

a - Hydraulic criteria met
b - Discharge at which 2 of 3 hydraulic criteria are met

PHABSIM Analyses

Spawning was identified as a critical life stage. The amount of physical area suitable for spawning was similar among transects as a function of flow (Figure 4). Spawning habitat peaked at 3.4, 3.8, and 3.2 cfs for the three transects, respectively. When the three transects are averaged, the peak occurs at 3.2 cfs. The three transects also exhibited secondary peaks in spawning physical habitat at higher flow levels, especially transect 3 which had a broad peak at 11 cfs. To decide whether the lower or higher flow level offered better spawning habitat, the suitability of individual cells on transects was examined (Table 5). The peak at 3.2 cfs comes from the sum of several cells with low spawning suitability. The peak at 11 cfs reflects 2 cells with high suitability and 2 more cells having lower suitability. Since normal flows during spawning are likely to be higher and such high flows create quality habitat, a flow of 11 cfs is recommended to maintain spawning habitat. The instream flow recommendation for the period from April 16 to June 30 is 11 cfs to maintain spawning habitat.

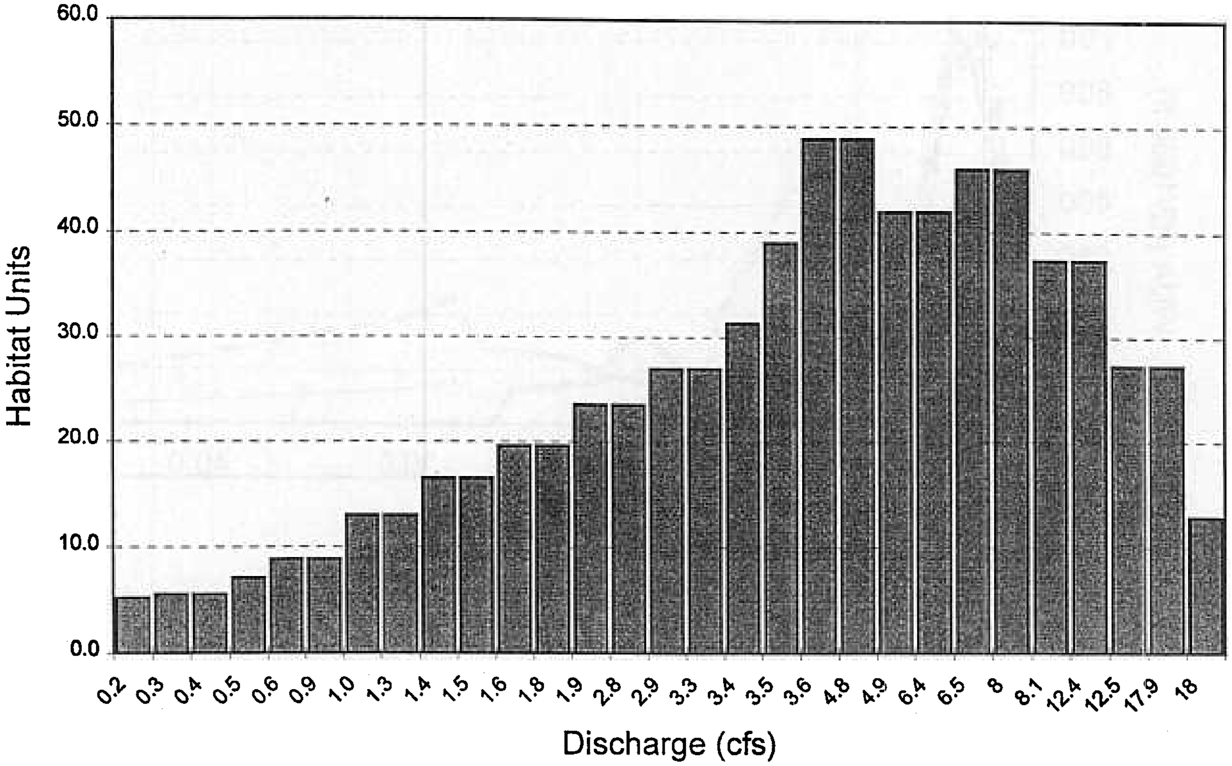

Figure 3. Trout habitat units at several late summer Currant Creek flow levels. X-axis discharges are not to scale.

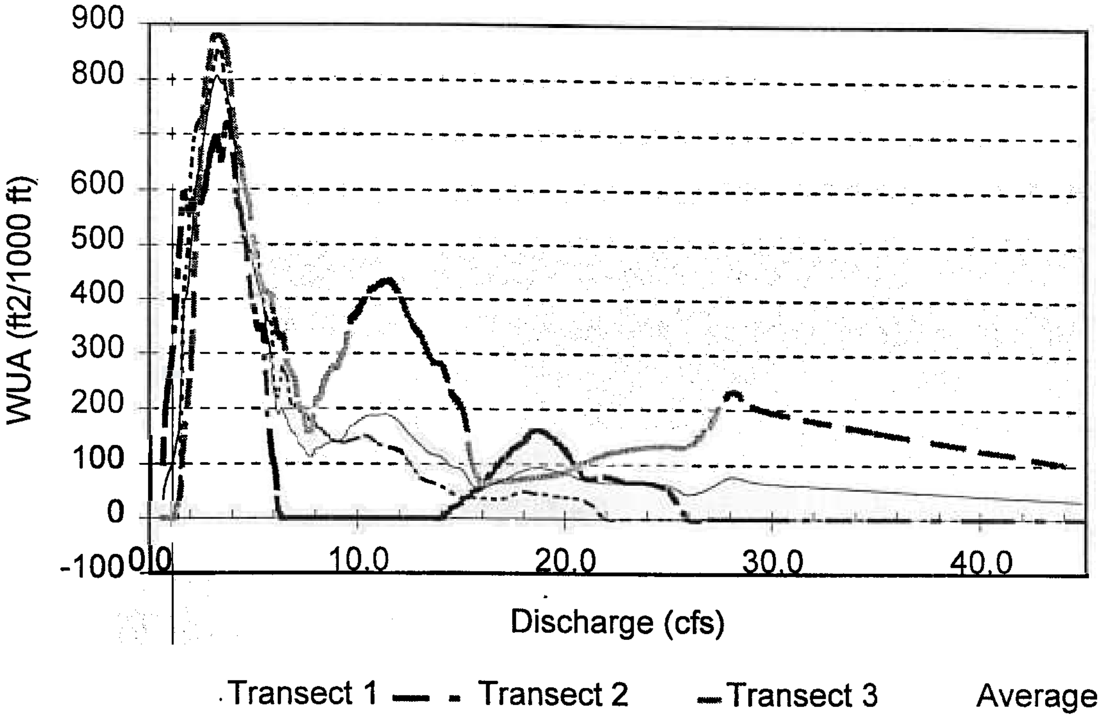

Figure 4. Relationship between stream flow and spawning habitat for three Currant Creek riffles.

Table 5. Numbers of PHABSIM cells that have low and high spawning suitability on each of three transects. Numbers are reported at the discharges at which physical habitat peaked.

	Transect	No. cells with low suitability (0.1 – 0.8)	No. cells with high suitability (0.8 – 1.0)
WUA peak at 3.2 cfs	1	7	0
	2	9	0
	3	12	0
WUA peak at 11 cfs	1	2	1
	2	0	0
	3	2	1

INSTREAM FLOW RECOMMENDATIONS

Based on the analyses and results outlined above, the instream flow recommendations in Table 6 will maintain the existing Currant Creek Colorado River cutthroat trout fishery when they are available in priority. The recommendations apply to an approximately 6 mile segment extending downstream from the confluence of the east and middle forks of Currant Creek at Township 13N, Range 106W, Section 1, NE1/4. The downstream boundary for the proposed instream flow segment is at Dry Hollow at the border between private and BLM at Township 14N, Range 106W, Section 5, SW1/4. Because data were collected from representative habitats and simulated over a wide flow range, additional data collection under different flow conditions would not significantly change these recommendations.

Table 6. Instream flow recommendations to maintain the existing Currant Creek trout fishery.

Time Period	Instream Flow Recommendation (cfs)
October 1 to April 14	1.2
April 15 to June 30	11
July 1 to September 30	3.6

This analysis does not consider periodic requirements for channel maintenance flows. Because this stream is unregulated, channel maintenance flow needs are adequately met by natural runoff patterns. If regulated in the future, additional studies and recommendations are needed for establishing channel maintenance flow requirements.

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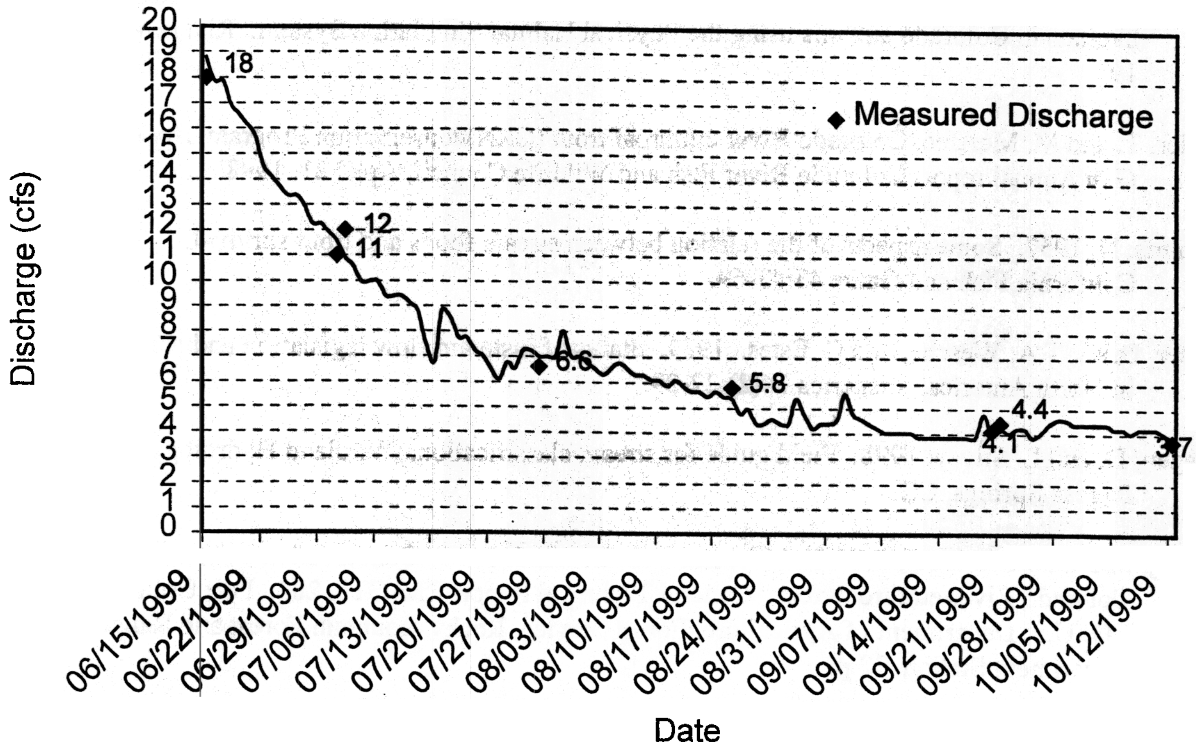
Appendix 1. Seasonal hydrograph recorded in 1999 at Dry Hollow, Currant Creek.



Appendix 2. Discharge and stage readings for Currant Creek at Dry Hollow.

Date	Discharge (cfs)	Stage Height (ft)
June 15, 1999	18	1.28
July 1, 1999	11	1.04
July 2, 1999	12	1.06
July 26, 1999	6.6	0.92
August 19, 1999	5.8	0.87
September 20, 1999	4.1	0.80
September 21, 1999	4.4	0.81
October 12, 1999	3.7	0.77
May 5, 1998	24	NA
June 17, 1998	10.3	NA
July 7, 1998	7.0	NA
September 17,1998	4.6	NA
October 7, 1998	3.8	NA
November 2, 1998	4.6	NA
*May 21, 1997	15.6	NA
*June 24, 1997	8.2	NA
*July 23, 1997	4.9	NA
August 21, 1996	2.9	NA

* 1997 flows were measured upstream at Jane's Meadow.

Appendix 3. Spawning suitability index data used in PHABSIM analysis. Index data are from Thurow and King, 1994.

Velocity	Weight	Depth	Weight	Substrate	Weight
0.00	0.00	0.00	0.00	0.00	0.00
0.59	0.00	0.32	0.00	4.00	0.00
0.69	0.10	0.34	0.10	4.10	0.10
0.94	0.20	0.37	0.20	4.20	0.20
1.10	0.50	0.45	0.50	4.30	0.50
1.12	1.00	0.52	1.00	4.40	1.00
1.72	1.00	0.82	1.00	5.60	1.00
1.82	0.50	0.97	0.50	5.70	0.50
2.06	0.20	1.27	0.20	5.80	0.20
2.26	0.10	1.58	0.10	5.90	0.10
2.31	0.00	1.75	0.00	6.00	0.00